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ABSTRACT

This document discusses the problem of teachers who teach primarily to the left hemisphere of the brain, not allowing the right-brain dominant student to expand his creative ability. It presents information about brain structure and function for educators. A glossary of 25 terms is provided with sources of the definitions. Annotations summarizing articles from professional journals and lay sources are provided. Ten annotations are included on the topic of functions of the cerebral hemispheres, six annotations are included on the topic of brain growth, and seven annotations are included on the topic of education and curriculum changes. The document concludes that modification of the curriculum at the middle school level will greatly improve the educational system, noting that the needs of right-brain children must be met and the specialized functions of each hemisphere must be enhanced. It is suggested that this type of holistic approach will meet the needs of all students, whether right or left hemisphere dominant. (The appendix includes diagrams of resident functions of left and right hemispheres and a comparison of Piagetian substages and Epstein spurt years.) (ABL)

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AN ANNOTATED BIBLIOGRAPHY OF LITERATURE DEALING WITH BRAIN FUNCTIONS AND BRAIN GROWTH

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Study in partial fulfillment of the requirements
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INTRODUCTION

The human brain has always been an intriguing part of human anatomy. Over the past twenty to forty years, neuroscientists and neuropsychologists have marveled at the many functions that are performed by the brain. In recent years, important discoveries by neuropsychologists on brain injured patients have led to new information on the cerebral cortex and the two hemispheres (Sperry).

Characteristics of the left cerebral hemisphere are:

1. Analytic reasoning.
2. Logical thought.
3. Verbal skills.
4. Math skills.
5. Linear operations.
6. Sequential processing.
7. Phonics, syntax, semantics.
8. Mediated intellect.

Characteristics of the right cerebral hemisphere are:

1. Synthetic reasoning.
2. Intuitive reasoning.
3. Spatial orientation.
4. Artistic endeavors, crafts.
5. Part-whole relationships.
6. Visual, spatial, emotional.
7. Holistic, relational.
8. Patterned, intuitive intellect.

(Yellin: 37)

Modern research has helped to solidify Piagets' theory of brain growth spurts and learning stages (Epstein, Toepfer). Similar research has shown that each cerebral hemisphere grows at different rates and stages (Thatcher, Walker, Giudice). Additional research by Grow and Johnson supported the growth stages of the brain in a different way. They discovered that the cerebral hemispheres do not grow and mature at the same rate for boys and girls.

Curriculum assessment has also been researched with its relationship to hemisphere functions. The role of readiness in learning at the middle school level is vital for educators (Strahan).

STATEMENT OF THE PROBLEM

Recent studies conducted on brain function have indicated that educators have been teaching primarily to the left hemisphere of the brain (Galin). This method of teaching has not allowed for the right-brain dominant person to expand his creative ability.

PURPOSE OF THE STUDY

The brain is a complex organ. In order for educators to unlock the full potential of their students, they must be able to comprehend brain structure and function to a degree. The purpose of this study is to present that information in an easily accessible format along with suggestions for curriculum change based upon what has been discovered.

ORGANIZATION OF THE STUDY

The study was divided into three sections. The first section explains the different functions of the two cerebral hemispheres. The second section explains the various stages and plateaus of brain growth. The third section denotes the curriculum changes that could be employed to enhance development of the right hemisphere, and also curriculum changes which better coincide with the stages of brain growth.

LIMITATIONS

A vast amount of research and opinionated articles have been conducted on the functions of each hemisphere and on brain growth. However, only a few articles of research have contradicted those findings, this was not enough information to substantiate any negative correlation.

Therefore, the research was geared to the realization that each hemisphere performs functions independently and simultaneously with the other hemisphere.

GLOSSARY

biofeedback -- the use of monitoring instruments to detect the body's physiological processes and to make the information available to the person involved. (Yellin 1983:38)

brain plasticity of development -- "the susceptibility to change of developmental processes or growth trends, in response to change in external or internal environment." (Good: 426)

cerebral cortex -- "layer of gray matter overlying the cerebral hemisphere and functioning chiefly in coordination of higher nervous activity." (Webster: 366)

cerebral hemisphere -- "either of the two lateral halves of the cerebrum." (Webster: 366)

cerebrum -- "the expanded anterior portion of the brain, consists of cerebral hemispheres and connecting structures, and is considered to be the seat of conscious mental processes." (Webster: 182)

cognitive -- "based on empirical factual knowledge." (Webster: 440)

coherence -- "is equivalent to the absolute value of the cross correlation function in the frequency domain and reflects the number and strength of connections between spatially distant generators." (Thatcher: 1110)

commissurotomy -- "surgical severing of the corpus callosum (Ornstein: 88)

convergent thinker -- "tend to pick one 'right' answer, assuming that there is a 'right' answer to every question." (Garrett: 243)

corpus callosum -- "the band of commissural fibers uniting the cerebral hemisphere in man and in higher mammals." (Webster:510)

divergent thinker -- "one willing to accept some uncertainty, tolerate error, and search for many answers." (Garrett: 243)

electroencephalogram (EEG) -- "an instrument designed to measure the functional levels of cerebral regions." (Rennels: 471)

grand mal -- "severe epilepsy." (Merriam-Webster: 312)

hemisphericity -- "the tendency for a person to rely more on one than the other cerebral hemisphere in processing information." (Torrance: 1982:29)

holistic -- an educational approach which views the whole person: physical, emotional, and cognitive abilities. (Yellin 1983:37)

intuitive -- "capable of knowing by direct insight or cognition." (Webster: 1187)

lateralization -- specialization of the right and left hemispheres of the brain for different functions. (Kane: 158)

mind maps -- "is an organizational skill which helps students to better comprehend a concept or an objective." (McClain: 2)

neurons -- cells that make up the brain. (Teyler: 2)

neuroscience -- "a branch of the life sciences that deals with the anatomy, physiology, biochemistry, or molecular biology of nerves and nervous tissue and esp. with their relation to behavior and learning." (Merriam-Webster: 471)

spatial -- "relating to or involving space." (Good: 547)

symmetry -- balance, evenness, uniformity. (Rogets: 423)

synapse -- "region of communication between two neurons (or between a neuron and a muscle)." (Teyler: 4)

ANNOTATIONS

FUNCTIONS OF THE CEREBRAL HEMISPHERES

Cone, Henry W. "Brain Research Findings May Improve Decision Making." National Association of Secondary School Principals. February, 1982. 66:67-72.

Cone conducted research involving the brain and its functions. However, instead of the traditional left-brain, right-brain hemisphere functions, Cones' research presented the theory of the triune brain. Cone credits the main study on the triune brain to P.D. MacLean of the National Institute for Mental Health. The decision making process, according to Cone's study, is found in the third level of the brain.

Gazzaniga, Michael S. "The Split Brain in Man." Scientific American. August, 1967. 217:24-29.

The author explained that the human brain is actually composed of two separate parts, the left hemisphere and the right hemisphere. The two hemispheres are connected by the corpus callosum, a bundle of fibers (p.24). His main study was the result of research on patients who had brain surgery separating the two hemispheres. Each hemisphere of the brain had to perform tasks separately. However, when the brain was not severed, both halves of the brain performed well together.

Hardyck, Curtis and Randy Haapanen. "Educating Both Halves of the Brain: Educational Breakthrough or Neuromythology." Journal of School Psychology. 1979. 17:219-230.

The authors re-evaluated previous studies conducted on right and left hemisphere functions of normal humans compared with the brain functions of patients who had undergone commissurotomy. This surgery splits the cerebral cortex allowing for study of each hemisphere individually. The authors drew three conclusions from their evaluations. First, they concluded that the patients who had undergone surgery were not a normal group to study. Secondly, they could find only extremely small differences in the hemispheric functions. Finally, they concluded that, until more evidence is presented, educators should not alter their curriculum or teaching method.

Kane, Nancy and Martin. "Comparison of Right and Left Hemisphere Functions." The Gifted Quarterly. Spring, 1979. 23:157-167.

The Kanes' study was a culmination of thirty years research on functions of the left and right hemispheres of the brain. They found that each hemisphere has its own specific function. The brain is flexible during the early growth years, but as a person gets older, "each side of the brain becomes specialized (lateralized) for different cognitive functions" (p.158).

Ornstein, Robert E. "Right and Left Thinking." Psychology Today. May, 1973. 6:87-92.

Robert Ornstein summarized research on human brain functioning in order to better understand how a person reacts when his brain has been surgically split. Ornstein studied the changes in relationship to each side of the brain. He discovered that each half specialized in a particular method of learning. The left hemisphere was based on logic, while the right was visual. Moreover, instead of working entirely separately, the two halves of the brain complement each other allowing for greater human achievement.

Rennels, Max R. "Cerebral Symmetry: An Urgent Concern for Education." Phi Delta Kappan. March, 1976. 57:471-472.

Rennel's research began when he discovered a sixteen year old boy who was not able to read. An electroencephalogram was done on the boy as well as spatial and perceptual tests. The results showed that the boy had a left hemisphere which had developed normally, but he had a highly developed and dominant right hemisphere. According to Rennels, educational institutions when emphasizing linear thought processes (which is a left hemisphere function), neglect a person's ability to visualize and imagine, or even to effectively use any visual or sensory stimuli (p.471). This boy could not read because he could not "visualize" it with his dominant right hemisphere. He recommends that educators need to concentrate more upon the development of neural symmetry rather than developing the left or the right hemisphere.

Sperry, Roger W., M.D. "Left Brain, Right Brain." Saturday Review. August, 1975. 30-33.

The results of Dr. Sperry's study contradicted the findings of many other experts. Dr. Sperry studied several cases of patients who had undergone split-brain surgery. He found that when the corpus callosum is split, each hemisphere of the brain has its own specialized functions (p.31). This study again brought brain function back into experimental science (p.33).

Sylwester, Robert. "Learning About Learning: The Neurosciences and the Education Profession." Educational Horizons. Summer, 1986. 64:162-167.

A Major development in neuroscience and a growing relationship between neuroscience and education were reported on by Sylwester. Neuroscientists had to overcome many research barriers such as the study of neurons. Research had previously focused on behavior rather than cognitive functions. The educational field must grow as new developments are made in neuroscience. Sylwester suggests a continued increased background in science for all educational leaders.

Torrance, E. Paul. "Hemisphericity and Creative Functioning." Journal of Research and Development in Education. Spring, 1982. 15:29-37.

The author conducted a study using graduate students who were administered a series of tests designed to assess creative style. The results showed a consistent tendency for creative style to be positively related to right hemisphere and negatively related to left hemisphere. Torrance did point out that there have only been a few studies done on younger subjects and these results were inconsistent. The author emphasized that even though creative thinking is a right hemisphere dominant thinking style, both left and right hemisphere are involved to complement each other.

Van Giesen, Angela, Mike Bell, and Darrell Roubinek. "Comparing Right and Left Brain Dominant Students on Reading Achievement Scores." Reading Improvement. Winter, 1987. 24:267-272.

The three authors' study revealed that the majority of teaching styles focus on verbal tasks within the left hemisphere of the brain. The authors also revealed in their findings that beginning reading programs have been geared toward the left hemisphere of the brain. These programs focused on placing letters into sequential order to produce words, and words into sequential order to produce sentences (p.267). Boys at a young age seem to have their right hemisphere develop at a more rapid pace than their left hemisphere. The authors concluded from this that boys will represent a higher percentage in lower reading groups than girls.

BRAIN GROWTH

Epstein, Herman. Education and the Brain. University of Chicago Press. 1978. 10:343-370.

The author concluded that, based upon his findings, the human brain grows in stages or spurts rather than at a continuous rate. These growth stages correlate with the growth stages proposed by Jean Piaget. Epstein's growth stages are: three to ten months, two to four years, six to eight years, ten to twelve years, and fourteen to sixteen or seventeen years. Epstein further pursued his study in the following areas: head circumference and age, in both males and females. He concluded that intensive intellectual input should be offered in the growth stages instead of the plateau stages. The results also showed that if children are exposed to intense studies during the plateau stages, rejection occurred and students became negative about school. This primarily happened between the ages of twelve and fourteen, prior to high school.

Grow, Meda F. and Norbert Johnson. "Math Learning: the Two Hemispheres." Journal of Humanistic Education and Development. September, 1983. 22:30-39.

The two authors, Grow and Johnson, intended to study the mathematical abilities of boys and girls throughout the growing years of children. First, they concluded that brain growth occurred in spurts, and that periods of rapid growth could be followed by periods of slow growth (p.31). The rapid growth spurts were between the ages of two to four, six to eight, ten to twelve, and fourteen to sixteen. Slow growth, or plateau periods, immediately followed each growth period. Secondly, they concluded that the two hemispheres of the cerebral cortex do not mature at the same rate for boys and girls (p.33). Finally, the two authors concluded that there should be some revision in our current educational system.

Hutson, Barbara. "Brain Growth Spurts-What's Left by the Middle School Years?" Middle School Journal. February, 1985. 16:8-11.

Dr. Hutson reviewed the theory on brain growth spurts proposed by Conrad Toepfer and Herman Epstein in 1978. Hutson's review of the theory is neither positive nor negative. Instead, she allows the reader to judge and come to a final decision. She presents the views of other authors on brain growth periodization and includes two charts to aid the reader in drawing his own conclusions. Hutson does agree, however, that after the middle school years there is very little brain growth.

Strahan, David B. "Brain Growth Spurts and Middle Grades Curriculum: Readiness Remains the Issue." Middle School Journal. February, 1985. 16:11-13.

David Strahan conducted a follow-up study to Barbara Hutson's on brain growth and curriculum for the middle school. Strahan concluded that part of Hutson's study had fallacies, particularly her interpretation of the brain growth periodization theory. Strahan also concluded that there are three valuable insights gained from the knowledge of brain growth spurts. One is the concrete reasoning that exists with middle school, the second is the varied differences of formal and informal assessments of reasoning. The third is the role of readiness in learning at the middle school level.

Thatcher, R.W., R.A. Walker, and S. Giudice. "Human Cerebral Hemispheres Develop at Different Rates and Ages." Science. May, 1987. 236:1110-1113.

The authors conducted a study of 577 children, ranging from two months to early adulthood. They used measurements from an electroencephalographic coherence to test the development of each of the cerebral hemispheres. The criteria used for selecting the children were based upon seven characteristics of mental and physical development. Also taken into consideration for the selectiion of children were the sex differences, 58% male 42% female; the racial color of children, 28% black and 72% white; and the intelligence quotient (IQ). The IQ ranged from 70-160 with a mean of 106.4. They found that the two cerebral hemispheres grow at different rates. Also some startling information surfaced during the study which led to the conclusion that different regions of each cerebral hemisphere develop at different rates and times.

Toepfer, Conrad F. Jr. "Brain Growth Periodization Data: Some Suggestions for Re-thinking Middle Grades Education." The High School Journal. March, 1980. 63:222-227.

Toepfer has demonstrated a fallacy in the organization of the educational system. He has proven that the human brain does not grow continually, at a steady rate, but instead grows in spurts. A plateau stage exists between each spurt. Toepfer's study revealed that the growth stages are: two to four years of age, six to eight years of age, ten to twelve years of age, and fourteen to sixteen plus years of age. The plateau stage of twelve to fourteen years of age is what the educational system needs to better handle. Based on his findings, Toepfer has shown that there are sufficient data and rationale to organize small and large group learning programs within the middle school. This will allow for individual students growth, permitting them to enter and leave the groups as they progress through the stages.

EDUCATION AND CURRICULUM CHANGES

Galin, David M.D. "Educating Both Halves of the Brain." Childhood Education. October, 1976. 53:17-20.

According to Dr. David Galin, educators have been teaching primarily to the left hemisphere of the brain. However, he claims in order to foster true creativity in students, both hemispheres need to be exercised. An educator must be able to blend the linear, logical approach of the left hemisphere with the intuitive, holistic style of the right and adapt his curriculum to employ both hemispheres actively.

Hauck, LaVerne. Jr. "Differences in Information Mapping Strategies in Left and Right Brain Learners." Resources in Education. December, 1985. ED270474.

The study undertaken by Hauck was intended to determine if information mapping would work as a learning technique for the right brain learner. Other factors beyond hemispheric dominance were reviewed including reading level, grade point average, and sex. The study consisted of over 400 eighth grade students both male and female. There was no significant difference with grade point average and hemispheric dominance. However, there was a significant difference between hemispheric dominance and reading levels and also learning test scores. Hauck concluded that the right brain learner performed better with information mapping in the areas previously mentioned.

Nummela, Renate M. and Tennes M. Rosengren. "What's Happening in Student's Brains May Re-define Teaching." Educational Leadership. May, 1986. 43:49-53.

The author's study focused on ways for teachers to enhance the learning process of their students in a non-threatening and natural environment. Learning is both a conscious and unsconscious process usually occurring simultaneously. Any external experience from a learning event is the result of related information that has been stored in the brain. Thus, the most effective way learning occurs is when any external sensory information results in one of the following: 1) recall existing information, 2) expand on existing information, 3) create new information (p.50). Our external processes (teaching methods) need to be re-defined to include the internal world of the students. This needs to take place when the lesson being taught is either too easy, or the student feels threatened in any way.

Shelby, A.V. "Is Your Teaching Style Frustrating Your Students?' Learning. 1985. 14:46-48.

The author, Alice Shelby, was a former teacher and is currently a free-lance writer. Her study focused on the development of different methods and techniques when teaching the younger student. The balancing of holistic and creative thinking with sequential and logical thinking draws all students into the learning process.

Sylwester, Robert. "Synthesis of Research on Brain Plasticity: The Classroom Environment and Curriculum Enrichment." Educational Leadership. September, 1986. 44:90-93.

According to Sylwester, educators need to create an environment that is enriched with a high potential for improvement. The brain follows a basic developmental pattern throughout its growth stages: 1) create an initial amount of connections within any related area, 2) use experience to help strengthen these connections, and 3) maintain flexibility to allow these connections to change.

Toepfer, Conrad F. Jr. "Curriculum Design and Neuropsychological Development." Journal of Research and Development in Education. 1982. 15:1-10.

Conrad Toepfer suggested that educators consult with neuroscientists and neuropsychologists when planning the school curriculum. This would benefit both teachers and students by allowing for a more precise plan depending upon what stage the child is at. It would also challenge students more by presenting new information during the growth stages and reviewing at the plateau stages.

Torrance, E.P. and Z.L. Rockenstein. "Styles of Thinking and Creativity." Gifted International. 1987. 4:37-49.

The two authors reviewed and studied literature on creativity, teaching techniques, and learning styles and strategies. Thinking styles and creativity are basically holistic. Even though learning styles may vary slightly from person to person, creativity is developed by each person through use of the entire brain. Torrance and Rockenstein continued to report that traditional teaching methods develop the left-brain creative person. Right-brain creative people actually use other parts of the brain simultaneously with the right cerebral hemisphere. So actually teaching methods that are geared to develop a right-brain student's ability, are also enhancing and developing the left cerebral hemisphere. A few teaching methods geared to develop the whole brain in each student are: "the creative-aesthetic approach, future scenario writing, and future problem solving" (p.43). All three encourage the use of the whole brain in learning and creative thinking.

SUMMARY

Research has indicated that the brain, which has been studied for many years, is a very unique organ. The brain is composed of two distinct parts, the left cerebral hemisphere and the right cerebral hemisphere. The two hemispheres are connected by a bundle of fibers called the corpus callosum (Gazzaniga).

Scientists have determined that each hemisphere has its own specialized functions. Some functions of the left hemisphere are mathematical, linear, verbal, writing, and logical. Some functions of the right hemisphere are visual, spacial, imagery intuitive, and artistic (Rennels, Ornstein). Neuroscientists and neuropsychologists have discovered that one of the cerebral hemispheres can dominate the other. Doctors Bogan and Vogel performed successful commissurotomies on several grand mal epileptic patients to reduce the number of seizures they experienced. From this, they determined that each hemisphere could independently function on its own (Ornstein, Sperry). A dispute to these findings was revealed by Hardyck and Haapanen. They concluded that epileptic patients were not a normal group to study. Secondly, they concluded from their research that only extremely small differences in hemispheric functions exist (Hardyck, Haapanen).

Additional research in the area of hemispheric functions led to the discovery of brain plasticity and brain growth in respect to the lateralization and cognitive functions of each hemisphere (Kane). Theories on brain growth and learning styles

were developed by Jean Piaget. Research has shown that the brain grows in stages or spurts rather than at a continuous rate throughout life (Epstein, Toepfer). These growth spurts occurred in two year intervals with a two year interval in between each growth spurt called a plateau (Epstein, Toepfer). Research that is similar to the studies done by Epstein and Toepfer proved that each cerebral hemisphere grows at different rates and spurts. Different regions of each cerebral hemisphere also proved to develop at different rates and times (Thatcher, Walker, Giudice).

Research done by Hutson did not support Epstein or Toepfer on brain growth spurts. A personal critique on the research of Epstein by McQueen disputed the findings on growth spurts. Data used by Epstein to support brain growth differences in boys and girls were "far too erratic to be used to demonstrate periodic growth, and more over, that brain growth has nearly stopped by age eight, with only a small percent of the brain's growth remaining" (McQueen: 67). Terrance Hines also refuted research on the different functions of the two hemispheres of the brain. "None of this left-brain/right-brain mythology is supported by the actual research on the differences between the left and right human cerebral hemispheres" (Hines: 32). "The real research findings on hemispheric differences have shown,... that differences in functions between the hemispheres, while very real and extremely interesting are, with the exception of vocal control, rather small and matters of degree. There is no evidence to support the claims that, for example, the left hemisphere is logical and the right intuitive..." (Hines: 34).

Educators have been primarily teaching to the left hemisphere

of the brain for many years. Teaching styles have focused on verbal tasks and linear tasks which are left hemispheric oriented (Galin, VanGiesen, et el.). Beginning reading programs, in the past, have been geared toward the left hemisphere. Letters were placed in sequential order to form words, and words in sequential order to form sentences (VanGiesen, et al.). Additional research has shown that traditional teaching methods have developed the left-brained creative person as well as the right-brained creative person. Creative people who are right-brained dominant simultaneously use other parts of the brain with the right cerebral hemisphere (Torrance, Rockenstein).

Research has further shown that educators and neuroscientists need to work together when planning school curriculum (Toepfer, Sylwester). Previous research had focused on behavior rather that cognitive functions (Sylwester).

Curriculum changes research has shown to be beneficial to the whole student and not just the left-brained student are: a creative-aesthetic approach, future scenario writing, and future problem solving (Torrence, Rockenstein). This research on curriculum design has proven beneficial for both teachers and students. By allowing for a more precise plan depending upon what stage the student is at (Toepfer). Research also revealed that true creativity in students exercises both hemispheres. Educators must blend the linear, logical of the left hemisphere with the intuitive, holistic style of the right and adapt the curriculum to employ both hemispheres actively (Galin).

CONCLUSION

Modification of the curriculum at the middle school level will greatly improve the educational system. Curriculum at this level needs to be altered to coordinate with the growth spurts and plateaus of brain development. The needs of right-brain dominant children must be met, as well as enhancing the specialized functions of each hemisphere. This type of holistic approach will meet the needs of all students, whether right or left hemisphere dominant.

RECOMMENDATIONS

The following recommendations are made for two purposes. First, the development of the right hemisphere dominant student in the classroom. Secondly, altering curriculum to coincide with brain growth spurts and plateaus.

Recommendations for the classroom are as follows:

1. Use visual aids when giving verbal instructions.
2. Use hand-outs and then read the instructions.
3. Re-state and paraphrase things for clarity.
4. Provide for role models to help illustrate concepts.
5. Use information mapping.
6. Use the creative-aesthetic approach.
7. Use future problem solving.
8. Use future scenario writing.
9. Use puzzles and other geometric shapes such as cubes and cylinders.
10. Continue to review and adjust the course sequence.
11. Educators need to work with neuroscientists and neuropsychologists when planning the curriculum.
12. Review material already presented during plateau stages of brain growth.

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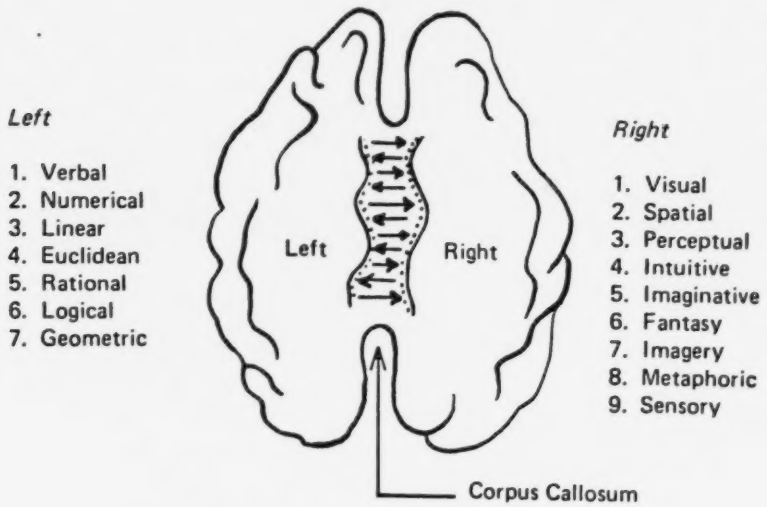
APPENDICES

APPENDIX A

Resident Functions of Left and Right Hemispheres

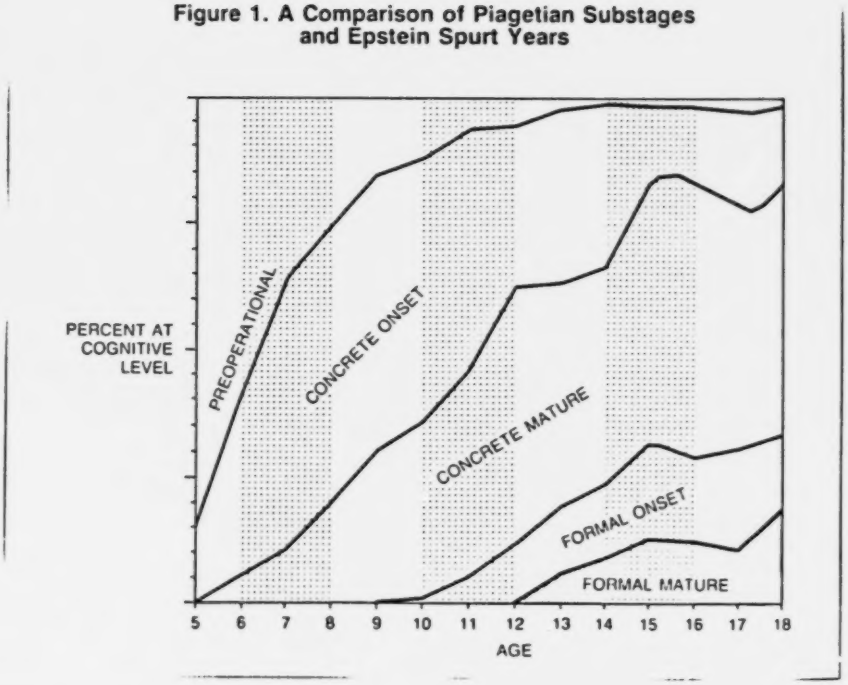
Resident Functions of Left and Right Hemispheres



APPENDIX B

A Comparison of Piagetian Substages and Epstein Spurt Years

Figure 1. A Comparison of Piagetian Substages and Epstein Spurt Years



BACKGROUND

NAME: James S. Kryder

EDUCATION: Indiana State University, B.S., 1973

Major: Physical Education - Secondary Education

Minor: Mathematics

Thirty-three hours graduate study in secondary education.

EXPERIENCE: Five years teaching at Tipton Middle School Tipton, IN in the field of Mathematics

Two years teaching at the Family & Children's Center, teaching both Mathematics and Physical Education.

One year teaching Mathematics at Marian High School.